MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

EME4096 – INTERNAL COMBUSTION ENGINE

(ME)

30 MAY 2019
09:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 6 pages including cover page with 4 Questions only.

2. Answer **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

A Spark Ignition (SI) engine, 2.4 liter, six cylinders operates on a four-stroke cycle at 5000 rpm, the compression ratio is 9.5. The engine has bore diameter of 10 cm. This engine is connected to a dynamometer which gives a brake output torque reading of 150 Nm. At that speed, air enters the cylinders at 90 kPa and 60 °C. The mechanical efficiency of the engine is 90%. Calculate the:

i) Stroke length, [m] **[2 marks]**
ii) Average piston speed, [m/s] **[2 marks]**
iii) Brake power, [kW] **[2 marks]**
iv) Indicated power, [kW] **[2 marks]**
v) Friction mean effective pressure, [kPa] **[6 marks]**
vi) Brake power per unit mass of gas in the cylinder, [kW/kg] **[8 marks]**
vii) Engine specific volume, [L/kW] **[3 marks]**

Question 2

a) With the help of a neat sketch, explain the effect of the compression ratio on the efficiency of the Otto cycle. Assume the specific heats, k = 1.4.

[5 marks]

b) A diesel engine four stroke cycle operating on the air standard Diesel cycle has single cylinders of 80 mm bore and 100 mm stroke. At the beginning of the compression the pressure and temperature of air are 1.03 bar and 40 ^{0}C respectively. If the clearance volume, V_c is 1/15 of the stroke volume and the cutoff ratio during combustion, β is 2.5, calculate:

i) the compression ratio

[2 Marks]

ii) the pressure and temperature at the relevant points of the cycle,

[15 Marks]

iii) the efficiency of the cycle

[3 Marks]

Assume the C_p and C_v of air to be 1.004 kJ/kg.K and 0.717 kJ/kg.K respectively

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Question 3

a) Explain how a carburated automobile engine is started on a cold winter morning; write what must be done, why and how?

[6 marks]

b) A 2.0 liter, six cylinder, four stroke cycle engine is equipped with multipoint port fuel injection, having one injector per cylinder. Maximum power is obtained at WOT with engine speed is 6500 rpm with stoichiometric gasoline and inlet pressure of 101 kPa. At idle condition, the engine speed is 550 rpm with stoichiometric gasoline and an inlet pressure of 25 kPa. Volumetric efficiency can be considered 90% at all conditions. Calculate the:

i) Fuel flow rate through an injector, [kg/s]

[5 marks]

ii) Injection pulse duration in seconds at idle conditions, [s]

[10 marks]

iii) Injection pulse duration in degrees of engine rotation at idle conditions, [degrees]

[4 marks]

Question 4

a) The single cylinder SI engine running at 2000 rpm and the spark plug is fired at 20^{o} bTDC. It takes 10^{o} of engine rotation to start combustion and get into flame propagation mode. Flame terminations occurs at 15^{o} aTDC. Bore diameter is 10 cm and the spark plug is offset 10 mm from the centerline of the cylinder. The flame front can be assumed as a sphere moving out from the spark plug. Calculate the:

i) Rotational angle during flame propagation, [degrees]

[2 marks]

ii) Time of flame propagation, [s]

[3 marks]

iii) Maximum flame travel distance, [m]

[2 marks]

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b) The engine exhaust gas dry analysis for a four-cylinder engine run on butene-1 C_4H_8 fuel is as follows:
CO_2 = 14.95%, C_4H_8 = 0.75%, N_2=84.3%, CO = 0%, H_2 = 0% and O_2 = 0%.
(Volume percentage = molar percent)

i) write the balanced combustion reaction equation of burning the fuel

[8 marks]

ii) calculate the actual fuel air ratio

[4 marks]

iii) estimate the stoichiometric air-fuel ratio

[4 marks]

iv) determine the equivalence ratio

[2 marks]

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Appendices

Table 1: Molecular weights

Substance		Molecular weight (kg/kgmole) or (lbm/lbmmole)
Air		28.97
Argon	Ar	39.95
Carbon	C	12.01
Carbon monoxide	CO	28.01
Carbon dioxide	CO_2	44.01
Hydrogen	H_2	2.02
Water vapor	H_2O	18.02
Helium	He	4.00
Nitrogen	N_2	28.01

Table 2: Thermodynamic Properties of Air

Temperature K	Temperature °C	c_p (kJ/kg-K)	c_v (kJ/kg-K)	$k = c_p/c_v$	Gas Constant $R = c_p - c_v$ (kJ/kg-K)
273	0	1.004	0.717	1.40	0.287
298	25	1.005	0.718	1.40	0.287
300	27	1.005	0.718	1.40	0.287
500	227	1.029	0.742	1.39	0.287
850	577	1.108	0.821	1.35	0.287
1000	727	1.140	0.853	1.34	0.287
1500	1227	1.210	0.923	1.31	0.287
2000	1727	1.249	0.962	1.30	0.287
2500	2227	1.274	0.987	1.29	0.287
3000	2727	1.291	1.004	1.29	0.287

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Table 3: Properties of fuels

Fuel		Molecular weight	Heating Value		Stoichiometric		Octane Number		Heat of Vaporization (kJ/kg)	Cetane Number
			HHV (kJ/kg)	LHV (kJ/kg)	(AF)s	(FA)s	MON	RON		
Gasoline	C_8H_{15}	111	47300	43000	14.6	0.068	80-91	92-99	307	40-55
Light diesel	$C_{12.3}H_{22.2}$	170	44800	42500	14.5	0.069			270	35-50
Heavy diesel	$C_{14.6}H_{24.8}$	200	43800	41400	14.5	0.069			230	
Isooctane	C_8H_{18}	114	47810	44300	15.1	0.066	100	100	290	
Methanol	CH_3OH	32	22540	20050	6.5	0.155	92	106	1147	
Ethanol	C_2H_5OH	46	29710	26950	9.0	0.111	89	107	873	
Methane	CH_4	16	55260	49770	17.2	0.058	120	120	509	
Propane	C_3H_8	44	50180	46190	15.7	0.064	97	112	426	
Nitromethane	CH_3NO_2	61	12000	10920	1.7	0.588			623	
Heptane	C_7H_{16}	100	48070	44560	15.2	0.066	0	0	316	
Cetane	$C_{16}H_{34}$	226	47280	43980	15.0	0.066			292	100
Heptamethylnonane	$C_{12}H_{34}$	178			15.9	0.063				15
α-methylnaphthalene	$C_{11}H_{10}$	142			13.1	0.076				0
Carbon monoxide	CO	28	10100	10100	2.5	0.405				
Coal (carbon)	C	12	33800	33800	11.5	0.087				
Butene-1	C_4H_8	56	48210	45040	14.8	0.068	80	99	390	
Triptane	C_7H_{16}	100	47950	44440	15.2	0.066	101	112	288	
Isodecane	$C_{10}H_{22}$	142	47590	44200	15.1	0.066	92	113		
Toluene	C_7H_8	92	42500	40600	13.5	0.074	109	120	412	
Hydrogen	H_2	2	141800	120000	34.5	0.029		90		

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